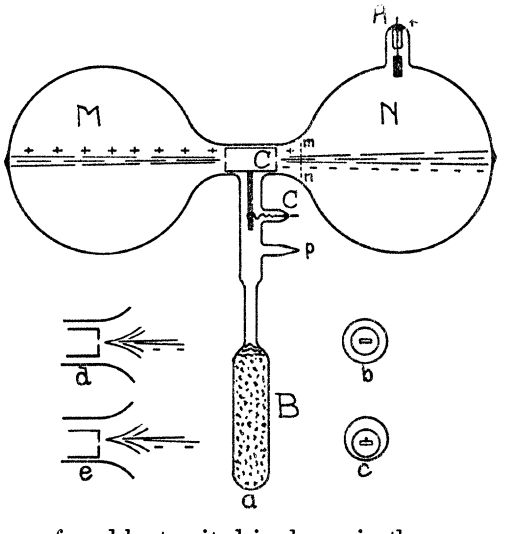
COLOR EFFECTS OF POSITIVE AND OF CATHODE RAYS IN RESIDUAL AIR, HYDROGEN, HELIUM, ETC.

As is well known positive rays have their origin in front of the cathode, and under the action of the electric force fall toward it. If the cathode is perforated the rays stream through and constitute the "kanal strahlen" of Goldstein. Tubes built to exhibit this phenomenon form a part of the regular equipment of nearly all collections of apparatus intended to exhibit the phenomena of electric discharge through gases.

Most beautiful and striking color effects may be had by using hollow cathodes[1] in specially designed tubes containing each a trace of some inert gas such as helium, argon or neon. The color effect is striking because the cathode beam is of one color, while the positive ray beam in the same gas is of an entirely different color. The general design of the tubes that Dr. Jakob Kunz and the writer



have found best suited is shown in the accompanying figure. The discharge tube is dumbbell shaped. It is made of two 2 liter Florence flasks, *M* and *N*. The hollow cylindrical cathode *C* is mounted in the neck, while the anode *A* is placed in one of the bulbs. The cathode terminal *C*, the nipple *p* for exhausting, and the charcoal bulb *B* are all attached to one vertical tube as shown.

The process of filling the discharge tube, sealing it off from the pump, and its subsequent use is as follows: After the tube is constructed, and the charcoal bulb *B* attached, the exhaust nipple is put in communication with a pump, and also to some source of the gas to be used. During the early part of the exhaustion it is well to gently heat the bulb *B*. Continue the pumping until the tube on sparking shows a tendency of becoming hard. As this stage is approached cathode rays will appear as a compact beam in the bulb *N*, while a beam of positive rays will traverse the bulb *M*. Now admit a small quantity of the desired gas, say, helium. The chances are that too much gas will enter the discharge tube and thus destroy the definition of the two beams. To restore it pumping should be continued and at the same time the bulb *B* should be carefully submerged in liquid air. Care must be exercised not to reduce the content of helium by too long continued pumping. The cooled charcoal will absorb the traces of air leaving the tube *MN* relatively richer and richer in helium—since helium, an inert gas, is but slightly absorbed by the cooled charcoal. The cathode beam in *N* as well as the positive ray beam in *M* will each increase in brightness and definition, reaching a maximum, after which, as the process continues, they will begin to fade. At the stage when the beams are judged brightest the exhaust nipple *p* is sealed off from the pump. The tube is now in its finished state. Removing the liquid air, the charcoal gives up its absorbed gas and the beams weaken and become diffused. For subsequent use it is only necessary to submerge *B* in liquid air while the discharge from an induction coil is passing. The beams in *M* and *N* will increase in brightness and definition as the absorption of the active gases proceeds, thus giving ample time for the observation of the changes going on within the tube.

The most interesting phenomenon is the *color* of the two beams. The cathode beam in helium is a greenish gray color, while the positive ray beam in the *same* gas is a beautiful red. There is no mistaking the colors. Indeed the red due to the positive ions is so persistent that it appears at the very origin of these rays—at the edge of the Crookes dark

[1] J. J. Thomson, "Rays of Positive Electricity," p. 6, 1913.

space in front of the cathode (shown by the dotted line *mn* in the figure).

The usefulness of the above described tube for many laboratories is limited because liquid air is used in its initial adjustment and subsequent operation. If desired the bulb *B* may also be sealed off. The only disadvantage is that this fixes the gas content in the tube. In case no liquid air is available it is still possible to construct the tube provided access may be had to a good pump. In this event the discharge tube should be washed out several times with the desired gas, in order to remove every trace of air, and then sealed off when the beams are brightest. This gives a permanent tube provided the occluded gases in the electrodes and walls of the vessel do not in time let the vacuum down. Danger from this source, however, may be largely avoided by gently heating the tube during exhaustion. The obvious advantage of a charcoal bulb is that the proper exhaustion can always be reached and at the same time the discharge at various stages of exhaustion successively exhibited.

It should be added that the best results only are obtained when the hollow cathode *C*, which is an aluminum cylinder closed at the ends with aluminum discs through the center of each is cut a rectangular opening about 1 mm. by 6 mm., is placed exactly on the axis of the tube connecting the bulbs *M* and *N*. The correct position is shown in the figure, end view at *b*, and side view at *d*. The discharge leaving the cathode, confined in a narrow tube as here, is always along the axis of the glass tube, regardless of the alignment of the cathode. In other words, the shape of the glass tube rather than the shape of the cathode determines the position of the cathode beam. Lack of alignment is shown at *c* and *e* where the opening through the hollow cathode is below the axis and as a result few positive rays get through and show in the bulb *M*, though they show distinctly at their origin in front of the cathode. To avoid possible lack of alignment it is advised to make the hollow cathode *C* of such diameter so as to fit snugly into the neck connecting *M* and *N* as shown in *a* of the figure.

An interesting test to show that the beam in *N* is composed of electrons, and that in *M* of positively charged ions, is to deflect them in turn by a strong electro-magnet. The cathode beam is readily deflected while the positive ray beam is but little deflected and that in the opposite sense. This is in full agreement with the theory of the magnetic deflection of moving positive and negative charges.

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THE AMERICAN CHEMICAL SOCIETY

THE fifty-first meeting of the American Chemical Society was held in Seattle, Washington, August 30 to September 3, 1915, inclusive. The members came to Seattle from many directions, although a special car brought thirty-three over the Great Northern railroad on the evening of the thirtieth. Those who came in the special car spent August 29 in Glacier National Park. The meeting was opened by an address of welcome by the dean of the University of Washington, to which response was made by President Herty. A general meeting was then called to order and listened to an address by Leo H. Baekeland on "Chemical Industry" and a second address by H. K. Benson on "Industrial Resources and Opportunities of the Pacific Northwest." Following these addresses the society continued in general session until noon of the following day, holding public symposiums.

On Wednesday afternoon the various additional programs were held as well as the election of additional officers for 1916. On the evening of the thirty-first a complimentary smoker was given by the Seattle Commercial Club, at which Professor Meany gave a beautifully illustrated lecture with colored slides on Mt. Rainier. The members were also entertained by a Japanese sword contest and by a Chinese cartoonist. Besides the usual attractions of the excursions and the President's address, the ladies were given special entertainment of a reception and tea on the university campus Tuesday, August 31, and an organ recital the same evening. On Wednesday they were given a special drive by automobile through the parks and boulevards of Seattle. On Wednesday the members were treated to an automobile trip through the beautiful parks and boulevards of Seattle and on Wednesday evening at 8 o'clock, President Charles H. Herty gave his presidential address, entitled "Co-